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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Adopt Biomethane Standards and Requirements, Pipeline Open Access Rules, and Related Enforcement Provisions.	Rulemaking 13-02-008

ASSIGNED COMMISSIONER'S RULING SEEKING COMMENT ON STAFF PROPOSAL ON RENEWABLE METHANE DEFINITION, JOINT UTILITY INTERCONNECTION TARIFF, AND CALIFORNIA COUNCIL ON SCIENCE AND TECHNOLOGY *UPDATED STATE OF SCIENCE REGARDING MAXIMUM PERMISSIBLE SILOXANE CONCENTRATION*

This Assigned Commissioner's Ruling seeks comment from interested parties on the attached Energy Division Staff Proposal titled "Staff Proposal for Definition of Renewable Methane" (Staff Proposal). The Staff Proposal is attached to this Ruling as Appendix A. Parties who wish to provide formal comments in response to Staff Proposal must file and serve them no later than December 7, 2018. Reply comments must be filed and served no later than December 21, 2018.

This assigned Commissioner's ruling also seeks comment on the proposed interconnection process (Joint Tariff Proposal) presented jointly by the utilities. The Joint Tariff Proposal is attached as Appendix B. Parties who wish to provide formal comments in response to Attachment B of the Joint Tariff Proposal must file and serve them no later than December 7, 2018. Reply comments must be filed and served no later than December 21, 2018.

Finally, this assigned Commissioner's ruling seeks comment on the California Council on Science and Technology *Updated State of Science Regarding Maximum Permissible Siloxane Concentration* (Updated Siloxane Opinion). This Updated Siloxane Opinion is attached as Appendix C. Parties who wish to provide formal comments in response to the Updated Siloxane Opinion must file and serve them no later than December 7, 2018. Reply comments must be filed and served no later than December 21, 2018.

IT IS RULED that:

1. Parties may file and serve comments in response to each Appendix to this ruling no later than December 7, 2018.

2. Parties may file and serve reply comments in response to each Appendix attached to this ruling no later than December 21, 2018.

Dated November 19, 2018, at San Francisco, California.

/s/ CLIFFORD RECHTSCHAFFEN
Clifford Rechtschaffen
Assigned Commissioner

Staff Proposal for Definition of Renewable Methane

Background

The Assigned Commissioner's Amended Scoping Memo and Ruling asked parties if biomethane injection standards should also apply to renewable methane and whether any criteria or verification requirements should be eliminated or changed. In comments to the Ruling, several parties pointed out that the Commission did not provide a definition for the term "renewable methane." Other parties provided their own definitions and/or urged the Commission to provide a definition of renewable methane.

Before considering whether renewable methane should be included in the utilities' gas rules, it is important to understand what it is. Therefore, the purpose of this proposal is to define renewable methane for the purposes of the IOUs' tariffs regarding pipeline injection of gas into their gas systems.

Summary of Comments on "Renewable Methane" Definition

In response to the Assigned Commissioner's Amended Scoping Memo and Ruling, Parties offer several definitions of renewable methane or similar terms like "renewable gas."

Southern California Gas Company (SoCalGas) and San Diego Gas and Electric Company (SDG&E) interpret renewable methane to mean "utilizing organic resources and excess renewable energy from sources like wind and solar to produce synthetic methane from hydrogen that can be injected into the existing natural gas pipeline, and later used as renewable natural gas, or feedstock to produce renewable electricity or renewable hydrogen using electrolysis or thermochemical conversion and methanation process."[1]

Pacific Gas and Electric Company (PG&E) proposes to define renewable methane as "thermochemical, biochemical, electrochemical, or processes other than anaerobic digestion, that are used to produce methane for the purpose of injection into the gas utility pipeline system."[2]

Harvest Power suggests defining renewable methane as "either (1) combining hydrogen produced from electrolysis or in another renewable manner and climate neutral CO2 to produce synthetic renewable methane or (2) hydrogen produced from electrolysis or in another renewable manner."[3]

The California Hydrogen Business Council (CHBC), Hydrogenics USA, Inc. (Hydrogenics), Bloom Energy Corporation (Bloom), and the National Fuel Cell Research Center (NFCRC) propose similar definitions for renewable methane. And while they differ in their exact wording, they generally define renewable methane as methane formed by combining hydrogen (generally

[1] SoCalGas and SDG&E Opening Comments at 6.
[2] PG&E Opening Comments at 8.
[3] Harvest Power Opening Comments at 4.

from electrolysis) with CO_2 that is renewable if the CO_2 is biogenic or captured from the air and the electricity is renewable.[4]

CHBC also notes that "renewable hydrogen combined with CO_2 fits into PG&E's definition of 'renewable methane' as being derived from 'thermochemical, biochemical, electrochemical, or processes other than anaerobic digestion, that are used to produce methane for the purpose of injection into the gas utility pipeline system.'"[5]

Finally, the Bioenergy Association of California (BAC), Clean Energy, and the California Association of Sanitation Agencies (CASA) do not provide a definition of renewable methane but rather urge the Commission to develop a definition. They add the caveat that any such definition should not include hydrogen or methane generated from fossil fuels or fossil-fuel based power.[6]

Discussion

While there are variations among the definitions and suggestions offered by the different parties, there are commonalities in their renewable methane definition proposals. First, renewable methane is formed by combining hydrogen and CO_2. Second, the hydrogen used in renewable methane formation should be sourced from organic material or water, which is a necessary feedstock for electrolysis. Third, CO_2 used in renewable methane formation should be biogenic or captured from the atmosphere. And lastly, renewable methane should not include hydrogen or methane generated from fossil fuels or fossil-fuel based power.

Another important consideration when defining renewable methane is that it should be distinct from biomethane. Decision (D.) 14-01-034 adopted the biomethane definition in Health and Safety Code §25420, which defines biomethane as being derived from biogas that is produced from the anaerobic decomposition of organic material. PG&E's suggestion that renewable methane should be derived from processes other than anaerobic digestion is therefore sensible as it would prevent gas that currently qualifies as biomethane from also qualifying as renewable methane.

Some parties also write that "climate neutral" CO_2, or a "source of CO_2 certified to be climate-neutral," should be considered an eligible feedstock for the creation of renewable methane.[7] While this could be a useful addition to the definition by providing leeway for future technologies and developments, we note that no party defines the term climate neutral or offers how, or by whom, climate neutrality would be certified and/or verified by the Commission.

Finally, it is important to define renewable energy and protect against double counting of Renewable Energy Credits. In order to establish consistency across programs, it is reasonable to adopt the same definition for renewable energy that is used in the Renewable Portfolio Standard (RPS) program. It is also reasonable to avoid double counting of renewable energy benefits by

[4] CHBC Opening Comments at 5, Hydrogenics Opening Comments at 9, Bloom Reply Comments at 2, and NFCRC Reply Comments at 2.
[5] CHBC Reply Comments at 4, footnote 4.
[6] BAC Reply Comments at 10, Clean Energy Reply Comments at 10, CASA Reply Comments at 8.
[7] Hydrogenics Opening Comments at 9 and CHBC Reply Comments at 5.

requiring that the renewable energy generation used to create renewable methane should not also be counted toward RPS compliance or claimed for any other program as renewable generation.

Staff proposal

"Renewable Methane" is proposed to be defined as:

> Renewable Methane is methane formed by combining hydrogen gas, sourced from non-fossil fuel-based organic material or water, with CO_2 that is biogenic or captured from the atmosphere, utilizing production processes other than anaerobic digestion. The direct energy inputs used to create renewable methane and the hydrogen gas used for renewable methane formation must be sourced from an eligible renewable energy resource, as defined in Public Utilities Code Section 399.12(e). Renewable energy inputs used to create renewable methane and the hydrogen gas used for renewable methane formation may not also be counted towards an RPS compliance obligation or claimed for any other program as renewable generation.

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DISCUSSION DRAFT OF JOINT UTILITY BIOMETHANE INTERCONNECTION TARIFF OF PACIFIC GAS AND ELECTRIC COMPANY, SOUTHWEST GAS CORPORATION, SOUTHERN CALIFORNIA GAS COMPANY, AND SAN DIEGO GAS & ELECTRIC COMPANY, AND BIOMETHANE INTERCONNECTION AGREEMENTS FOR WORKSHOP DISCUSSIONS

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Pursuant to the Assigned Commissioner's Amended Scoping Memo and Ruling dated July 5, 2018 (Scoping Memo), Pacific Gas and Electric Company (PG&E), Southwest Gas Corporation (Southwest Gas), Southern California Gas Company (SoCalGas), and San Diego Gas & Electric Company (SDG&E) (collectively, the Joint Utilities)[1/] respectfully submit a draft joint utility biomethane interconnection tariff and identify utility biomethane interconnection agreement approaches for discussion at the upcoming workshop outlined in the Scoping Memo.[2/]

I. INTRODUCTION

The Joint Utilities strongly support the Commission's efforts to encourage and facilitate the interconnection of biomethane supplies in the State. This effort can help increase renewable gas in the pipeline for transportation and stationary end uses, and is an important step in reducing carbon in the gas system to contribute to California's short-lived climate pollutant and greenhouse gas reduction goals.[3/] The Joint Utilities look forward to the planned workshop to

1/ Pursuant to Rule 1.8(d), PG&E has been authorized to file this document on behalf of the Joint Utilities.

2/ The Joint Utilities believe the upcoming interconnection workshop should focus on ensuring the safe and timely interconnection of biomethane resources, focusing on the nine topics identified in the Scoping Memo. The Joint Utilities support other workshops and subsequent phases of this proceeding to advance the renewable gas industry through discussions on gas quality and other issues addressed in parties' Opening and Reply Comments on the Scoping Memo.

3/ Assembly Bill (AB) 32 (Nunez, Pavley), Senate Bill (SB) 32 (Pavley), AB 1900 (Gatto), AB 2196 (Chesbro), SB 1122 (Rubio), SB 840 (Budget), AB 2313 (Williams), SB 605 (Lara), SB 1383 (Lara), *ARB's Short-Lived Climate Pollutant Reduction Strategy* and *California's 2017 Climate Change Scoping Plan* available at https://arb.ca.gov/cc/scopingplan/scopingplan.htm.

work with stakeholders to help identify safe, efficient solutions to any interconnection-related obstacles that suppliers may face.

The Joint Utilities are seeing substantial interest and activity in interconnecting biomethane supplies from a variety of feedstocks. PG&E has recently signed an interconnection agreement with a biomethane supplier using its proposed California Biomethane Interconnection and Operating Agreement (PG&E CBIOA), which is currently under consideration by the Commission pursuant to Advice Letter 3946-G-A, discussed below. Additionally, PG&E is currently in varying stages of the biomethane project development process with approximately ten different producers. SoCalGas and SDG&E currently have two operational producers on its system and is in varying stages of the biomethane project development process with approximately twenty-seven different project sites. In addition, there are nine more sites that have made interconnection inquiries in 2018. Southwest Gas is also currently in the biomethane project development process with one producer at one site, and two additional sites have made inquiries.

As reflected in the Scoping Memo's list of interconnection workshop topics,[4/] the Joint Utilities note that there are at times significant differences between the utility gas systems, operational procedures and commercial positions that should be reflected in a utility's tariffs and forms. For example, perspectives on credit risk, termination provisions, and conditions for physical delivery or operation of the assets will differ based on a multitude of factors. These differences will develop over time and continuously evolve with new issues, conditions, and enhancements in operational efficiency. In light of this changing landscape, the Joint Utilities believe it is important to exercise a measure of caution in creating a highly prescriptive tariff or a process that does not enable the necessary flexibility to address unique issues for the industry or each individual utility.

4/ The first workshop topic listed is: "1. Workability: is a joint utility interconnection tariff for biomethane workable? a. If not, what needs to be utility specific and why?" Scoping Memo at p. 7.

The Joint Utilities have prepared a discussion draft of a joint utility biomethane interconnection tariff that follows the project development process and serves as a resource for a biomethane producer on how to interconnect with a California utility gas pipeline system.

For purposes of discussion at the interconnection workshop, the Joint Utilities also have summarized the existing Commission-approved and pending Commission approval biomethane interconnection agreements currently used by the utilities. As part of the workshop, the Joint Utilities look forward to understanding developers' interconnection process-related concerns and hearing how to improve their interconnection processes and forms in order to achieve the shared goal of interconnecting biomethane supplies in the State as safely and expeditiously as possible consistent with the Commission's cost responsibility and other orders. The workshop may also consider potential conflicts with a utility's other commercial practices and operating processes, how to consider previously litigated tariff issues, and efforts to enhance existing agreements to facilitate biomethane interconnections.

II. OVERVIEW OF CURRENT UTILITY BIOMETHANE INTERCONNECTION TARIFFS AND FORMS

To aid the Commission and stakeholders in the interconnection workshop discussions, the following is a summary of the current tariffs and forms used by the respective Joint Utilities to interconnect biomethane suppliers.

A. PG&E

PG&E uses a combination of its Gas Rule 21.H[5/] (Open Access Interconnection of New Gas Supply) and the PG&E CBIOA to establish the processes for a biomethane producer to interconnect with its gas system.

Gas Rule 21

Gas Rule 21.H generally provides that PG&E will provide non-discriminatory interconnection to its pipeline system for an Applicant to deliver new gas supply. Upon interconnection, PG&E will provide open access transportation of the gas under its applicable

5/ https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS_RULES_21.pdf.

rate schedules, rules and transportation agreements. PG&E will perform interconnection-related work subject to the terms and conditions set forth in Gas Rule 21 and the applicable provisions, including, but not limited to, the gas quality requirements and testing. The Applicant must execute a standard "Agreement to Perform Tariff Schedule Related Work" (Form 62-4527[6/]), which contains a description of the work to be performed by PG&E, the cost estimate, and payment terms. The Applicant and PG&E execute the PG&E CBIOA and other agreements prior to final interconnection and gas flow.

California Biomethane Interconnection and Operating Agreement (Advice Letter approval pending)

PG&E filed Advice Letters 3946-G and 3950-G on March 2, 2018, seeking Commission approval of a proposed *pro forma* PG&E CBIOA and California Production Interconnection and Operating Agreement (PG&E CPIOA) detailing the interconnection and operating processes necessary for both biomethane and natural gas producers to access and use PG&E's gas system.[7/] After receiving protests to these filings and extensive outreach with stakeholders,[8/] PG&E incorporated stakeholder input and filed revised versions of the proposed PG&E CBIOA and PG&E CPIOA supplemental Advice Letters 3946-G-A[9/] and 3950-G-A[10/] on April 16, 2018. The supplemental filings were not protested and are currently under consideration by the Commission.

6/ https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS_FORMS_62-4527.pdf.

7/ PG&E's existing California Production Interconnection and Operating Agreement, in use in its current form for approximately the past 21 years to interconnect natural gas supplies, was not a filed form. In Advice Letters 3946-G and 3950-G, PG&E submitted separate interconnection and operating agreements for natural gas and biomethane supplies, updated the terms of its existing interconnection and operating agreement, and filed the agreements for Commission approval as *pro forma* agreements.

8/ PG&E received protests to Advice Letter 3946-G from the Agricultural Energy Consumers Association (AECA) and DVO, Inc. (DVO).

9/ https://www.pge.com/tariffs/assets/pdf/adviceletter/GAS_3946-G-A.pdf.

10/ https://www.pge.com/tariffs/assets/pdf/adviceletter/GAS_3950-G-A.pdf.

The PG&E CBIOA, filed only months ago, is reflective of the biomethane market today, and already has been executed successfully with a biomethane supplier.[11/] PG&E significantly modified its existing Interconnection and Operating Agreement to address numerous industry concerns and improve the interconnection process, including specifically for biomethane suppliers. Cumulatively, PG&E believes these proactive steps have led to an increase in the activity of biomethane projects working through the process. As detailed in its advice letter filing, PG&E proposes to use the PG&E CBIOA for the interconnections going forward and recommends that the Commission use the PG&E CBIOA as a basis for discussion at the planned interconnection workshop in this proceeding.

B. SoCalGas/SDG&E

Gas Rule 39

SoCalGas and SDG&E Rule 39 (Access to the SoCalGas and SDG&E Pipeline System)[12/] generally provides that the Utility shall provide nondiscriminatory open access to its system to any party (hereinafter "Interconnector") for the purpose of physically interconnecting with the Utility and effectuating the delivery of natural gas, subject to the terms and conditions set forth in Rule 39 and the applicable provisions of the Utility's other tariff schedules including, but not limited to, the gas quality requirements set forth in Rule No. 30 Transportation of Customer-Owned Gas, I. Gas Delivery Specifications and J. Biomethane Delivery Specifications.[13/] The Interconnector and Utility must execute the Commission-approved form agreements and the Interconnector pays the costs the utilities incur in providing access, except where otherwise provided by the Commission.

11/ To the extent the Commission modifies the pro forma PG&E CBIOA, PG&E and the producer will terminate the executed PG&E CBIOA and execute the final, Commission-approved PG&E CBIOA per Section 15(a)(i)(C).

12/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/39.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE39.pdf.

13/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/30.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE30.pdf.

Interconnection Agreements

SoCalGas and SDG&E currently use the base Interconnection Agreement, Form 6450 and Form 143-005[14/], Interconnect Collectible System Upgrade Agreement, Form 6430 and Form 143-006[15/] and Operational Balancing Agreement, Form 6435 and Form 143-007[16/] or with CPUC approval, the California Producer modifications to those forms.

SoCalGas and SDG&E propose to use the California Producer form agreements, Form No. 6454 California Producer Interconnection Agreement[17/] (CPIA) and Form No. 6456 California Producer Interconnection Collectible System Upgrade Agreement[18/] (CPICSUA) and, if applicable, Form No. 6458 California Producer Agreement for Transfer of Ownership[19/] (CPATO), since biomethane producers have been citing many of the same attributes (small, varying production, etc.) cited by California Producers and the Commission in D.07-08-029[20/] establishing those forms.

The interconnection process is designed to provide a clearly defined, but very flexible, path(s) to enable interconnectors to initially screen potential interconnection sites and volumes and then progressively, with increasing cost and time, include a more comprehensive scope of work and increasingly accurate cost estimate to enable interconnectors to ultimately make a final investment decision based on (1) a description of all costs of construction, (2) complete engineering construction drawings, and (3) all construction and environmental permit applications and right-of-way acquisition requirements.[21/]

14/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/IA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-005.pdf.

15/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/ICSUA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-006.pdf.

16/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/OBA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-007.pdf.

17/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPIA.pdf

18/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPICSUA.pdf

19/ https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPATO.pdf

20/ http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/71690.PDF.

21/ Takeaway services are separately governed by Schedule G-BTS Backbone Transportation Services, https://www.socalgas.com/regulatory/tariffs/tm2/pdf/G-BTS.pdf.

SoCalGas recommends that the Commission use its California Producer forms as a basis for discussion at the planned interconnection workshop in this proceeding given: (1) the extensive Commission proceeding history and the balancing of interconnectors, ratepayer and utility interests represented by that history, (2) the successful and broad application to existing and new producers,[22/] (3) the very complete yet flexible nature of the engineering process, and (4) that they are more likely to support biomethane development.

C. Southwest Gas

Gas Rules 2, 21 and 22

Southwest Gas Rules 2, 21 and 22[23/,24/ ,25/] provide the general terms and conditions that apply when Southwest Gas transports customer-secured natural gas through its pipeline system or elects to procure biomethane gas from a producer that interconnects with Southwest Gas' pipeline system. Southwest Gas' interconnection agreement is currently under development.

III. DISCUSSION DRAFT OF JOINT UTILITY BIOMETHANE INTERCONNECTION TARIFF

The Joint Utilities have prepared a discussion draft of a joint utility biomethane interconnection tariff that follows the project development process and functions as a central resource for biomethane suppliers seeking to interconnect with a utility pipeline system. As outlined below at a high level, this interconnection process is the same for each of the Joint Utilities. The draft interconnection tariff is designed to: (a) facilitate the initiation of biomethane supply projects by providing a roadmap for biomethane producers of each utility's mechanism for implementing the biomethane project development process; and (b) identify the steps necessary for each project to advance from engineering through to construction and release to operations, as outlined below. See Attachment A for the draft Joint Utility Interconnection

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22/ SoCalGas entered into over fifty agreements with existing California Producers in 2015 with an effective date of January 1, 2016, completed another California Producer interconnection in 2018 and is currently nearing completion of a biomethane interconnection pursuant to the California Producer agreements.

23/ https://www.swgas.com/1409184602439/rule2.pdf.

24/ https://www.swgas.com/1409184638657/RULE_21--Eff.-April-25.pdf.

25/ https://www.swgas.com/1409181853334/RULE_22--Biomethane-Gas---effective-October-8.pdf.

Tariff, which is intended to serve as the starting point for further discussion at the upcoming interconnection workshop.

A. Description of Work Performed at Each Stage in the Biomethane Project Development Process Common to the Joint Utilities

Although each utility currently utilizes its own tariff and interconnection forms for interconnecting biomethane supplies, there are common stages that each utility implements as part of the biomethane project development process that should form the basis of any Joint Utility Biomethane Interconnection Tariff:

Developer Intake

In this phase, the utility sends the developer a request for general project information, including contact information, delivery volumes at full project build-out, gas delivery pattern, and the project location. When this information is received from the developer, the utility will perform a capacity study.

Capacity Study

The utility will assess the ability of the pipeline system to receive delivery of the developer's gas on a 24x7 basis. Any constraints that limit the utility's ability to receive the forecasted delivery volumes will be identified. If the developer elects to move forward with the project, a contract will be executed, funding will be advanced, and the utility will begin to design the receipt point facilities as described below.

Preliminary and Detailed Engineering Designs

The utility and developer project teams will engage to discuss the project, and the utility will develop a preliminary design and an initial cost estimate. If the developer wishes to continue project development, the project teams will move forward to design the necessary receipt point facilities.

The utility will complete the final facility design, produce a final cost estimate, and deliver all documents necessary for the construction facilities.

Construction and Interconnection to the Pipeline

The utility or developer (developer may use utility approved contractors, materials and vendors to construct the facilities) will construct the necessary facilities and release the receipt point to operations.

The Joint Utilities believe that there may be common processes that could be standardized across the utilities, such as initial interconnection intake forms, to simplify the project development process. However, while the project intake form and process may be relatively straightforward, each utility will differ in its approach to analyzing available system absorption capacity, project design, and construction practices. The Joint Utilities welcome input during the workshops on opportunities for improved efficiency that benefits the biomethane industry.

IV. UTILITY BIOMETHANE INTERCONNECTION AGREEMENTS FOR DISCUSSION DURING INTERCONNECTION WORKSHOP

As outlined above, for purposes of discussion at the interconnection workshop the Joint Utilities have identified (a) the existing Commission-approved California Producer interconnection agreements used by SoCalGas and SDG&E for biomethane projects, and (b) PG&E's recently proposed PG&E CBIOA, currently pending approval by the Commission.[26/] Rather than making wholesale revisions to existing interconnection agreements, the Joint Utilities recommend that the workshop focus on possible enhancements to existing agreements to facilitate biomethane interconnections.

In general, the Joint Utilities believe that the current gas supply project interconnection processes and forms in place are being used effectively to interconnect biomethane projects to the utility pipeline system, though the Joint Utilities recognize stakeholders may have feedback on the process and make recommendations for improvements.

The Joint Utilities look forward to participating in the planned interconnection workshop and to providing information on their interconnection processes and how they apply to

26/ Southwest Gas' interconnection agreement is currently under development.

biomethane producers, and to hearing from biomethane producers about any obstacles to interconnection that have been encountered. With that knowledge, the parties can have an informed discussion on the potential value, costs, and tradeoffs of developing common interconnection processes and agreements.

V. CONCLUSION

The Joint Utilities appreciate the opportunity to provide the attached discussion draft of a joint utility biomethane interconnection tariff and to provide an overview of their biomethane interconnection agreements and look forward to discussing these materials in detail at the planned interconnection workshop, as well as to continued collaboration with stakeholders to advance biomethane interconnections in California.

Respectfully submitted,

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By: */s/Jonathan D. Pendleton*
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October 3, 2018

ATTACHMENT A

Draft Joint Utility Interconnection Tariff

This Rule outlines the general process for a renewable natural gas (RNG) Producer to interconnect with a utility gas system in California. The California gas utilities, Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), Southern California Gas Company (SoCalGas), and Southwest Gas Corporation (Southwest Gas), follow the same overall process for interconnecting new RNG supplies. This Rule is designed to: (a) facilitate the initiation of RNG supply projects by providing a roadmap for Producers of each Utility's mechanism for implementing the project development process; and (b) identify the steps necessary for each project to advance from engineering through to construction and release to operations, as outlined below Producers who wish to interconnect and deliver RNG must comply with all terms and conditions set forth in a Utility's applicable Gas Rules[1], and sign the applicable utility agreements, including interconnection, operating and balancing agreements.

The process for interconnecting new supplies of RNG to utility gas systems in California is summarized below.

I. Capacity Study

Producer provides Utility with project information, including but not limited to, project location, gas volume, and the gas supply source. Utility performs a feasibility study to determine the Utility's available capacity to transport Producer's gas from the interconnection point.

A. PG&E

Producer completes Request for Gas Supply Interconnection form and PG&E completes a capacity study.

1. Description

The capacity study is a high-level, non-binding desktop analysis that identifies the nearest PG&E pipeline that has sufficient capacity to receive Producer's gas, customer demand, and compatible gas quality for the estimated RNG volumes.

B. SoCalGas and SDG&E

Producer submits written request for an Interconnection Capacity Study and SoCalGas conducts pursuant to Consulting Services Agreement (CSA) Form 6440, Exhibit A Interconnect Capacity Study and Form 6410 Exhibit B Confidentiality Agreement[2].

1. Description

Based on Producer's written request for access, which includes where, when the new supply will be delivered to the Utility and the volume(s) required to be received, the Utility determines its downstream capability to take natural gas away from the interconnection point and the

[1] SoCalGas' and SDG&E's Rules 30 and 39, and Preliminary Statement Part IV, Income Tax – Contributions & Advances or Section VI, Miscellaneous Accounts, Income Tax Component Of Contributions And Advances Provision (ITCCAP); PG&E's Gas Rules 14, 21, associated Forms and Preliminary Statement Part P; Southwest's Gas Rules 2, 21 and 22.

[2] https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CSA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-002.pdf

associated Utility facility enhancement costs that are required to add the requested takeaway capacity on both a Displacement Receipt Point Capacity basis and Expansion Receipt Point Capacity basis, or just a Displacement Receipt Point Capacity basis. All analyses shall take into consideration new supplies and facilities that have been or will be installed pursuant to a previously executed Collectible System Upgrade Agreements (CSUA) in effect. Priority for purposes of determining facility costs will be established on the basis of the date a party executes a CSUA. The cost estimate provided in the Interconnection Capacity Study will not include cost estimates for land acquisition, site development, right-of-way, metering, gas quality, permitting, regulatory, environmental, unusual construction costs, and operating and maintenance costs. The Capacity Study step also provides interconnectors with the option to request a deviation from the gas quality specifications pursuant to SoCalGas' Rule 30[3], Paragraph I.5.

C. Southwest Gas

Producer completes Southwest Gas Renewable Natural Gas Supplier Interconnection Project Fact Sheet, and Southwest Gas conducts an Initial Feasibility Study.

1. Description

Southwest Gas conducts a review of the system's actual gas flow/usage data and hydraulics modeling of the system to determine its capability to take the proposed biomethane injection. Additionally, facility requirements, including, a basic concept design and preliminary budgetary cost estimate for the required facilities is compiled.

II. Preliminary and Detailed Engineering Designs

Preliminary Design

Utility develops a preliminary design and cost estimate for the Utility to take the RNG away from the identified interconnection point.

Detailed Design

Utility develops a detailed design to determine the estimated investment decision costs based on issued for construction drawings and schedule for the Utility to take the RNG away from the identified interconnection point.

A. PG&E

Producer completes Request for Design Scope and Preliminary Estimate. PG&E develops a Design Scope and Preliminary Cost Estimate.

[3] https://www.socalgas.com/regulatory/tariffs/tm2/pdf/30.pdf and http://regarchive.sdge.com/tm2/pdf/GAS_GAS-RULES_GRULE30.pdf for SoCalGas and SDG&E, respectively.

1. Description

Preliminary Design

Producer shall execute a standard "Agreement to Perform Tariff Schedule Related Work" (Form 62-4527) which shall contain a description of the work to be performed by PG&E, the cost estimate and payment terms. Producer provides an initial engineering advance to PG&E.

Producer shall execute a California Biomethane Interconnection and Operating Agreement (PG&E CBIOA) and/or receipt point exhibit(s), or California Production Interconnection and Operating Agreement (PG&E CPIOA) receipt point exhibit(s), as necessary.

PG&E will prepare an initial design scope and preliminary engineering cost estimate for the expected facilities and provide the estimate to Producer. Producer will inform PG&E whether or not to proceed with detailed design.

Detailed Design

Producer will execute additional "Agreement to Perform Tariff Schedule Related Work" (Form 62-4527) forms as needed. Producer is responsible for paying all costs in advance of PG&E's performance of the interconnection work scope, as described in the PG&E CBIOA/PG&E CPIOA.

PG&E shall provide Producer with (i) an estimate of the PG&E Costs to design, construct, install and commission the facilities, and (ii) an estimate of the design costs alone should Producer elect to construct and install the facilities as allowed under the PG&E CBIOA/PG&E CPIOA, and Producer shall pay the amount of the applicable estimate as mutually agreed.

Long lead time equipment will be ordered as agreed between the Utility and Producer project teams.

B. SoCalGas and SDG&E

1. Description

The Preliminary Engineering Study expands upon the Interconnect Capacity Study scope of work to include the point of receipt, land acquisition, site development, right-of-way, metering, gas quality, including Producer requested gas quality deviations, a non-site specific Btu district enhancements , permitting, regulatory, environmental, unusual construction, and, operating and maintenance costs pursuant to Form No. 6440 Consulting Services Agreement (CSA)[4] and its Exhibit A-1, Preliminary Engineering Study.

Upon formal written request, the detailed engineering study (DES) is then completed pursuant to Exhibit A-2, Detailed Engineering Study of the CSA form and will: (1) describe all costs of construction, including any needed Btu district or other system changes (2) develop complete

[4] https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CSA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-002.pdf.

engineering construction drawings, and (3) prepare all construction and environmental permit applications and right-of-way acquisition requirements.

If the Producer elects, long lead material procurement can also be added to the DES scope of work pursuant to the CSA Exhibit A-3, Detailed Engineering Study with Long Lead Material Procurement.

Alternatively, the Producer also has the option to have the Utility complete the PES and DES, without or with long lead material procurement, in parallel.

In addition, the Producer has the option to have the Utility complete the DES, procurement, construction and commissioning pursuant to the applicable CPIA and CPICSUA form agreements.

Any required takeaway enhancements are completed pursuant to Form 6420 Collectible System Upgrade Agreement (CSUA).[5]

C. Southwest Gas

Southwest Gas completes a specific design and estimate.

1. Description

Southwest Gas develops a preliminary design based on the feasibility study. A cost estimate is provided to the Producer based on the preliminary design and a Letter of Agreement is generated. Once the Letter of Agreement signed and all required information is provided by the Producer, a full design and cost estimate are created by Southwest Gas.

III. Construction and Interconnection to Pipeline

Utility proceeds with construction of facilities to take the RNG away from the identified interconnection point.

A. PG&E

PG&E or the Producer will construct the interconnection facilities, which may include, but are not limited to, taps, valves, piping, measuring equipment, odorizing equipment, land rights, permits and communication equipment.

A true up of all account payments for estimated costs versus actual costs will be performed. Final project costs will be trued-up after completion of all project work.

Producer shall pay for any computer programming changes to PG&E's scheduling and nomination systems.

[5] https://www.socalgas.com/regulatory/tariffs/tm2/pdf/Access-CSUA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-003.pdf.

B. SoCalGas and SDG&E

Utility then proceeds with procurement and construction of the interconnect including the interconnecting pipeline, any Btu district and scheduling changes, and any required takeaway enhancements.

Another alternative, following utility completion of the Interconnect Capacity Study, is for Interconnector to request the Utility to complete the Preliminary and Detailed Engineering Studies pursuant to the CPIA and CPICSUA.

1. Producer and Utility must execute Form No. 6454, California Producer Interconnection Agreement[6] (CPIA) and Form No. 6456 California Producer Collectible System Upgrade Agreement[7] (CPICSUA).
2. If Producer elects to design and/or build they do so per CPICSUA Exhibit D, Self-Build Alternative and transfer ownership per Form 6458 California Producer Agreement for Transfer of Ownership[8] (CPATO)
3. Takeaway system enhancements are done pursuant to Form 6420 Collectible System Upgrade Agreement[9] (CSUA).

C. Southwest Gas

Southwest Gas proceeds with final design and construction of the interconnect.

1. Interconnector and Utility must execute Biogas and Renewable Natural Gas (RNG) Services "RNG Interconnection and Transportation Agreement".[10]

IV. Acceptance and Gas Delivery

Producer's renewable gas supply at the interconnection point shall comply with all PG&E tariffs and rules prior to Release to Operations. Producer shall conform to all applicable laws and regulations, pre-injection and pre-operational testing, notification and recordkeeping requirements as directed by the CPUC or other agencies.

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6 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPIA.pdf
7 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPICSUA.pdf
8 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPICSUA.pdf
9 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/Access-CSUA.pdf; http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SF_143-003.pdf.
10 Currently under development.

A. PG&E

1. Gas Rule 21, Transportation of Natural Gas[11]
2. Gas Rule 14, Capacity Allocation and Constraint of Natural Gas Service[12]
3. Gas Preliminary Statement—Part P (Income Tax Component of Contributions Provision)[13]
4. California Production Balancing Agreement (CPBA) (Form 79-944)[14]
5. Gas Transportation Service Agreement (Form 79-866)[15] and Exhibit A – Gold Coast Firm or As-Available Transportation Service (Form 79-866-A)[16]
6. Agreement to Perform Tariff Schedule Related Work" (Form 62-4527)[17], California Biomethane Interconnect Operating Agreement (PG&E CBIOA)[18] and/or receipt point exhibits or 2018-filed California Production Interconnection and Operating Agreement (PG&E CPIOA)[19] receipt point exhibits

B. SoCalGas and SDG&E

1. Gas Rule 39, Access to the SoCalGas Pipeline System[20]
2. Gas Rule 30, Transportation of Customer Owned Gas[21]
3. Preliminary Statement, Part IV – Income Tax - Contributions and Advancements (ITCCA)[22] or Income Tax Component of Contributions and Advancement Provision (ITCCAP)[23] for SDG&E
4. Form No. 6452, California Producer Operational Balancing Agreement[24] (CPOBA)
5. Schedule G-BTS, Backbone Transportation Service[25]

11 https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS_RULES_21.pdf
12 https://www.pge.com/tariffs/tm2/pdf/GAS_RULES_14.pdf
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24 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/CPOBA.pdf
25 https://www.socalgas.com/regulatory/tariffs/tm2/pdf/G-BTS.pdf

C. Southwest Gas

1. Gas Rule 2, Description of Service[26]
2. Gas Rule 21, Transportation of Customer-Secured Natural Gas[27]
3. Gas Rule 22, Biomethane Gas[28]
4. Preliminary Statement 13, Income Tax Component of Contributions and Advances[29]
5. Forms as noted above are being developed.

[26] https://www.swgas.com/1409184602439/rule2.pdf
[27] https://www.swgas.com/1409184638657/RULE_21--Eff.-April-25.pdf
[28] https://www.swgas.com/1409181853334/RULE_22--Biomethane-Gas---effective-October-8.pdf
[29] https://www.swgas.com/1409184639108/Preliminary-Statement--Eff-January-28.pdf

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CCST Facilitated Expert Opinion

The Updated State of Science Regarding Maximum Permissible Siloxane Concentration

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The Steering Committee has reviewed this CCST facilitated expert opinion. We unanimously agree that this document does not change any of the findings, conclusions, or recommendations of the CCST report "Biomethane in California Common Carrier Pipelines: Assessing Heating Value and Maximum Siloxane Specifications," rather this strengthens the basis of our findings, conclusions and recommendations.

CCST Facilitated - Expert Opinion

The Updated State of Science Regarding Maximum Permissible Siloxane Concentrations

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This note provides additional information pertaining to the treatment of siloxanes made available subsequent to the completion of the recent California Council on Science and Technology (CCST) report "Biomethane in California Common Carrier Pipelines: Assessing Heating Value and Maximum Siloxane Specifications" (Von Wald et al. 2018). CCST reports are a reflection of the body of scientific knowledge at the time of publication and are final upon completion. Therefore, this CCST-facilitated expert opinion is independent of the study.

This CCST-facilitated expert opinion was requested by the California Public Utilities Commission (CPUC) and is focused on a review of one research study; it therefore does not aim to represent a review of the full body of relevant literature. While one study may add to the broader body of scientific knowledge, it may do so only incrementally. Biogas is a renewable gaseous energy resource generated from the anaerobic decomposition of the organic components of wastes and biomass. Biogas can contain a wide range of trace constituents, which vary depending on the source of the biogas. Siloxanes are a family of silicon-containing trace constituents found in biogas from wastewater and landfill sources. It is well-documented that combustion of gas containing siloxanes results in silica (SiO_2) formation which can cause damage to appliances via clogging and reduction of airflow and/or deactivation of key sensors or catalysts (Nair et al. 2012, 2013, Gersen et al. 2013, Turkin et al. 2014). In order to protect pipeline-connected equipment, the current maximum siloxane specification in California is set at 0.1 mg Si/m^3. The California state legislature, in Bill SB 840, requested that the California Council on Science and Technology (CCST) complete a study that investigated the state of knowledge surrounding the maximum siloxane specification.

One of the major findings of the recent CCST report was the lack of data availability regarding the impact of siloxanes on combustion appliances (Von Wald et al. 2018). Only a handful of such studies have been conducted, without clear implications supporting a specific numerical standard. Since the publication of the CCST report, a new study on siloxane impacts on combustion appliances has been published (Gersen et al. 2019). Because of the paucity of data from prior studies, we review the implications of this study for the CA siloxane standard below.

Summary of new information

Gersen et al. conducted experiments on a set of seven residential gas-fired appliances. The studied appliances included one hot water heater and six natural gas boilers (two partially premixed, four fully premixed). The appliances had various heat exchanger materials and geometries. All six boilers employed an ionization safety device to detect the presence of a flame, which shuts off the gas supply when the sensor current falls below a specified threshold. The experimentation was performed in two stages. All seven appliances were tested with a natural gas containing 11.2 mg Si/m^3. In a second stage, the four most sensitive were selected for further testing at levels of 6.3, 2.8, and 1.5 mg Si/m^3. These siloxane concentrations are notably lower than previous experimental work, and therefore these data may provide a more meaningful result for understanding potential impacts of siloxanes at the levels considered for regulation. In addition, the sample size in this study is larger than in prior studies, where a total of 9

pieces of equipment have been studied across prior studies (Turkin et al. 2014, Gersen et al. 2013, Nair et al. 2012, 2013).

The effect of silica deposition was investigated for three modes of appliance failure: (1) increase in carbon monoxide (CO) emissions, (2) decrease in thermal output of the appliances and (3) failure of the ionization safety device.

CO emissions of the hot water heater were found to increase considerably over time due to clogging of the heat exchanger and decreased airflow through the device. Decreased airflow leads to incomplete combustion which results in CO formation. No increase in CO emissions was observed in the two partially-premixed boilers, due presumably to a different geometry of the heat exchangers. The CO emissions of the four fully-premixed boilers were found to remain constant as the control system for these appliances adjusts the flow of fuel to ensure a proper fuel/air ratio and avoid incomplete combustion.

Similarly, the thermal output from combustion in the appliances was governed by airflow. As mentioned above, the four fully premixed boilers adjust the fuel flow to maintain the desired fuel/air ratio. As such, rather than produce CO emissions, these appliances will decrease the flow of gas and reduce thermal output. This feature is uncommon in the U.S appliance population.

Experiments on the boilers confirmed that deposition of silica can deactivate the ionization safety device. However, one notable result of this work was that the relationship between the concentration of siloxane and the time to failure of the flame sensor is nonlinear. The time to failure is shown to increase exponentially as the siloxane concentration decreases. This nonlinearity is confirmed by thermodynamic calculations for equilibrium of siloxane combustion. At lower concentrations of siloxane, the equilibrium state at high temperatures will retain more of the silicon in the gas phase, thus reducing the solid deposition on surfaces and sensors near the flame zone (such as the ionization probe).

The experimental results of Gersen et al. (2019) were used to develop a mathematical relationship between the volume of gas burned over the lifetime of an appliance and the maximum concentration of silicon that would be allowable to avoid premature failure. These models are given in eq. 1-4 of Gersen et al. (2019). The models are based on experimental data from the most sensitive appliances of the set, so that results would be appropriately conservative for the other tested appliance geometries. Gersen et al. estimate that, for the studied appliances, in order remain below recommended CO emissions (0.02 CO/CO_2 ratio, approximately 2,000 ppm CO air-free), the siloxane concentration ought not exceed 0.44 mg Si/m^3. In order to avoid thermal input reductions exceeding 10%, the results recommend a siloxane concentration of less than 0.23 mg Si/m^3. Finally, to avoid failure of the ionization safety device, siloxane concentrations should be below 0.45 mg Si/m^3. These concentration results are specific to the thresholds applicable in that study region.

We can apply these models to typical California gas consumption volumes for a residential boiler (1500 m^3/year) and water heater (400 m^3/year) assuming lifetimes of 15 years. The models were modified to conform with U.S.-specific requirements. The recommended Weaver thermal input reduction maximum is 5% per Kelton (1978), while the CO emissions standard is 400 ppm air-free per Gas Consultants Inc (2009). As the relationship between CO emissions and mass of silica build-up is nonlinear, the model for this failure mode was adjusted to the new emissions threshold using the data available in Figure 3 of Gersen et al (2019). The results of applying these models under these conditions are displayed in Table 1 below.

Table 1. Result from applying Gersen et al. (2019) failure models to California-specific conditions to estimate a maximum siloxane concentration.

Failure mode	**Maximum Siloxane Concentration**
Exceed CO emissions guidance (water heater)	0.30 mg Si/m^3
Reduce thermal input by 5% (boiler)	0.14 mg Si/m^3
Ionization safety device failure (boiler)	0.47 mg Si/m^3

Table 1 shows that the results of applying the Gersen et al. (2019) equations confirm the order of magnitude of the current California siloxane specification (0.1 mg Si/m^3).

By testing seven residential appliances at siloxane concentrations as low as 1.5 mg Si/m^3 this study has increased the number of relevant data points available for informing regulation of siloxane concentrations in gaseous fuels. Its results also require less extrapolation to generate estimates of failure time for appliances under regulated gas quality. However, there remains significant uncertainty about the implications for real-world conditions in California due to the small sample sizes of all studies to date.

Addressing limitations and caveats

One limitation of this approach is that these models were developed for a specific set of seven residential appliances, based on the experimental data from the most sensitive appliances. The appliances tested were new, whereas in-place appliance populations may have existing degradation that increases their susceptibility to damage by silica deposition. Furthermore, it is unclear how generalizable the tested appliances are to the stock of California residential combustion appliances, as inventories of appliance type and vintage would be needed. There remains imperfect information for other end-users that may be more sensitive to siloxanes than the residential customers. However, it is generally assumed that larger consumers of gas will also have more robust protocols in place for system monitoring and maintenance.

Conclusions

While data on the impact of siloxanes are still limited, the Gersen et al. (2019) study gives evidence that supports the current California specification of 0.1 mg Si/m^3. Gersen et al. (2019) has nearly doubled the number of data points available regarding the modes of failure in residential combustion appliances, and tested gas with lower siloxane concentrations than previous studies. Testing of gas with lower concentrations is useful because the results require less extrapolation than prior studies. Importantly, in direct experiments at 1.5 mg Si/m^3 (no extrapolation required), short term damage was observed in residential appliances.

Applying the Gersen et al. (2019) models to California conditions supports the order of magnitude of the existing California siloxane specification of 0.1 mg Si/m^3. The above numerical results appear to represent a slight relaxation of the existing California specification. However, 0.1 mg Si/m^3 is within the margin of uncertainty introduced by temporal extrapolation and generalization from small sample size. Additional studies would be needed to determine whether relaxing the current siloxane specification is safe. This CCST-facilitated expert opinion does not supersede the siloxanes recommendation in the full report (Von Wald et al. 2018). Rather it provides an additional body of evidence to be considered by the CPUC.

The Steering Committee has reviewed this CCST facilitated expert opinion. We unanimously agree that this document does not change any of the findings, conclusions, or recommendations of the CCST report "Biomethane in California Common Carrier Pipelines: Assessing Heating Value and Maximum Siloxane Specifications", rather this strengthens the basis of our findings, conclusions and recommendations."

Works cited

Gas Consultants Inc., (2009). *Gas Interchangeability Testing Report*. Prepared for Air Conditioning, Heating, and Refrigeration Institute, American Gas Association, and Association of Home Appliance Manufactures.

Gersen, S., Visser, P., van Essen, V. M., Dutka, M., Vainchtein, D., de Hosson, J. T. M., & Levinsky, H. B. (2013). Effects of silica deposition on the performance of domestic equipment. In *Proceedings of the European Combustion Meeting* (pp. 25-28).

Gersen, S., Visser, P., van Essen, M., Brown, M., Lewis, A., & Levinsky, H. (2019). Impact of silica deposition on the performance of gas-fired domestic appliances caused by the combustion of siloxanes in the fuel. *Renewable Energy*, *132*, 575-586.

Kelton, K., (1978). Appliance performance and changes in gas composition (Paper 78-D-52). Operating Section Proceedings: American Gas Association, Arlington, Virginia, American Gas Association, pp. D-107–D-111.

Nair, N., Zhang, X., Gutierrez, J., Chen, J., Egolfopoulos, F., & Tsotsis, T. (2012). Impact of siloxane impurities on the performance of an engine operating on renewable natural gas. *Industrial & Engineering Chemistry Research*, *51*(48), 15786-15795.

Nair, N., Vas, A., Zhu, T., Sun, W., Gutierrez, J., Chen, J., ... & Tsotsis, T. T. (2013). Effect of siloxanes contained in natural gas on the operation of a residential furnace. *Industrial & Engineering Chemistry Research*, *52*(18), 6253-6261.

Turkin, A. A., Dutka, M., Vainchtein, D., Gersen, S., van Essen, V. M., Visser, P., ... & De Hosson, J. T. M. (2014). Deposition of SiO2 nanoparticles in heat exchanger during combustion of biogas. *Applied Energy*, *113*, 1141-1148.

Von Wald, G. A., Brandt, A. R., Rajagopal, D., Stanion, A. (2018). *Biomethane in California Common Carrier Pipelines: Assessing Heating Value and Maximum Siloxane Specifications.* Sacramento, CA: California Council on Science and Technology.